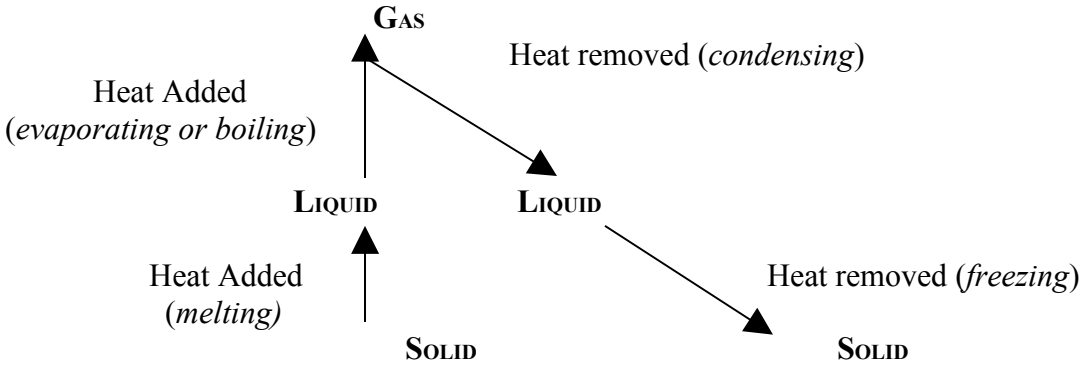
Heat and Changes in Matter

3-4 The student will demonstrate an understanding of the changes in matter that are caused by heat.

3.4.2 Explain how water and other substances change from one state to another (including melting, freezing, condensing, boiling, and evaporating).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 2nd grade (2-4.2), students exemplified matter changing from a solid to a liquid and from a liquid to a solid. Students have not been introduced to the terms for these changes or how heat is involved in previous grades. In 4th grade (4-4.1), students will summarize the processes of the water cycle, including evaporation and condensation. In 5th grade (5-4.2), students will compare the physical properties of the states of matter (including volume, shape, and the movement and spacing of particles). -

It is essential for students to know that water and other substances can change from one state to another with either heat is added or removed. The diagram below shows the relationship between heat and the changes of state:



Melting
- *Melting* occurs when a solid is heated enough to change to a liquid.
- When solid ice *melts*, it changes to liquid water.
- Ice *melts* at 0°C or 32°F.

Freezing
- *Freezing* occurs when a liquid cools enough (heat is removed) to form a solid.
- When liquid water freezes, it changes to solid ice.
- Water freezes at 0°C or 32°F.
- Water will expand when it freezes; other substances contract.

Evaporation
- *Evaporation* occurs when liquids change to gases rather slowly at the surface of the liquid as heat is added from their surroundings.

NOTE TO TEACHER: Evaporation occurs at any temperature.

Boiling

- *Boiling* also is the change from a liquid to a *gas* but faster with bubbles of gas forming in the liquid at a given temperature because a lot heat is being added from a source.
- Water boils at 100°C or 212°F. When substances are heated, they will expand and take up more space.

Condensing

- Condensing occurs when a gas is cooled enough (heat is removed) to form a liquid.
- For example, condensation occurs, when liquid water is visible on the outside of a glass of ice water.
- The water vapor or gas in the air is cooled when it contacts the cold surface of the glass.
- Another example of condensation is when liquid water droplets form on the cool surface of the mirror in the bathroom from hot water vapor produced by the shower.
- The water vapor in the air condenses on the cool mirror.

It is not essential for students to know the temperatures at which melting, boiling, or freezing occur in other substances besides water.

Assessment Guidelines:
The objective of this indicator is to *explain* how water and other substances change from one state to another; therefore, the primary focus of assessment should be to construct a cause-and-effect model to show how heat causes melting, evaporating, and boiling and how cooling (removing heat) causes condensing and freezing. However, appropriate assessments should also require students to *summarize* the processes by which substances change from one state to another by being either heated or cooled; *interpret* a diagram of changing states of matter with heating and cooling; *compare* various matter changing states by being heated or being cooled; or *identify* the processes by which matter changes from one state to another.